# Assigning Treatments to Segments Needing Work in Network-level Pavement Management

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StreetSaver®

*Keeping good roads good!*

# Outline

- Management Levels

- Importance of treatment assignment

- Methods of treatment assignment

- Decision trees (StreetSaver®)

- How to change them

- How to select treatments, costs, etc.

- Keeping them current

- Questions

# Infrastructure Asset Management
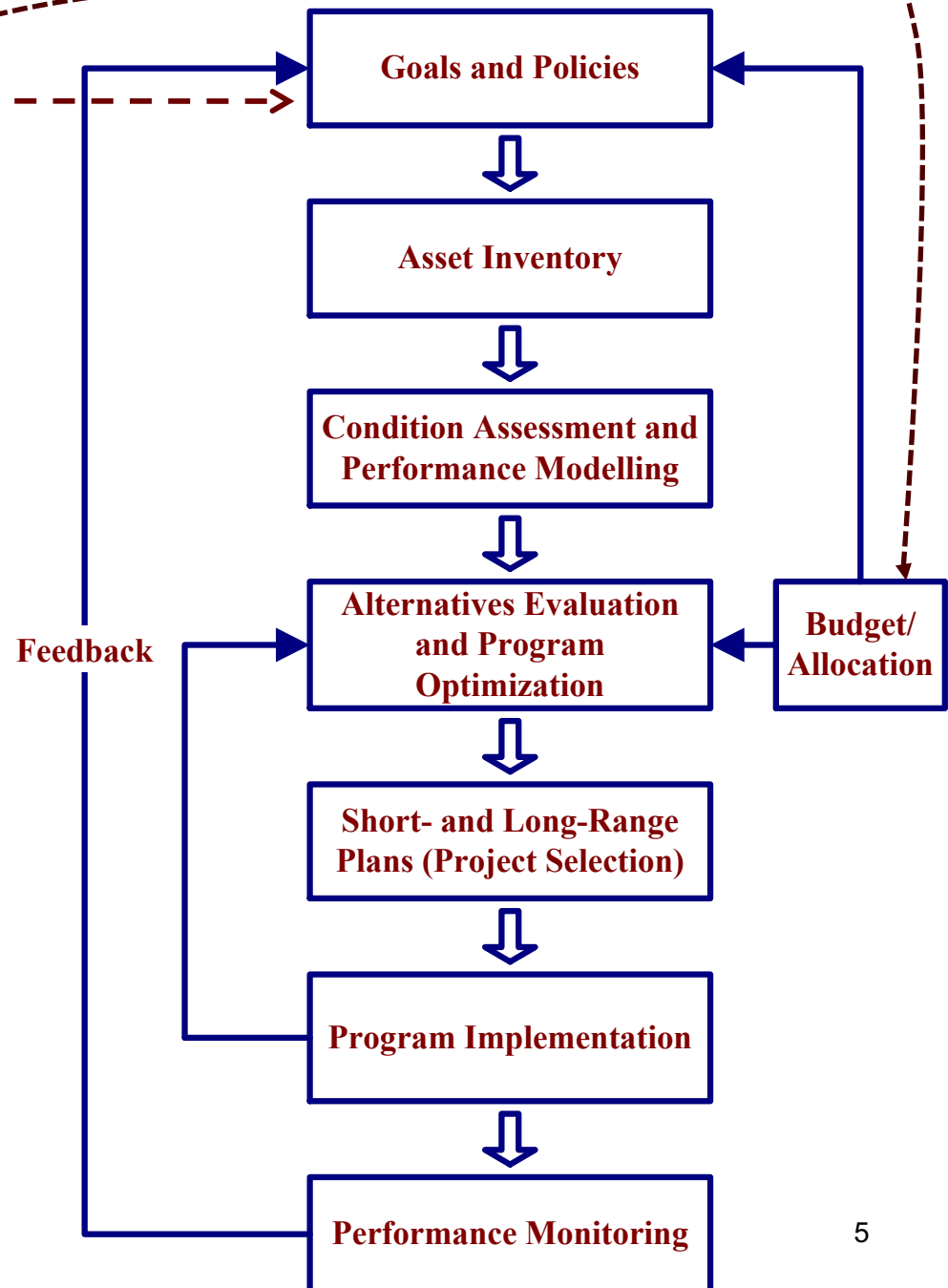
- A **Decision Making Process**

- Used to make cost-effective decisions about
  - Design,
  - Construction
  - Maintenance
  - Rehabilitation
  - Retrofit or
  - Abandonment

# Infrastructure Management Decision Support Systems

- Computerized decision support systems

- Decision support tools used by agency personnel to

  - Provide quantified information to support cost-effective decisions

- **_Key elements_** include _models that connect funding to levels of service provided over time_

Input from Elected Officials & Citizens
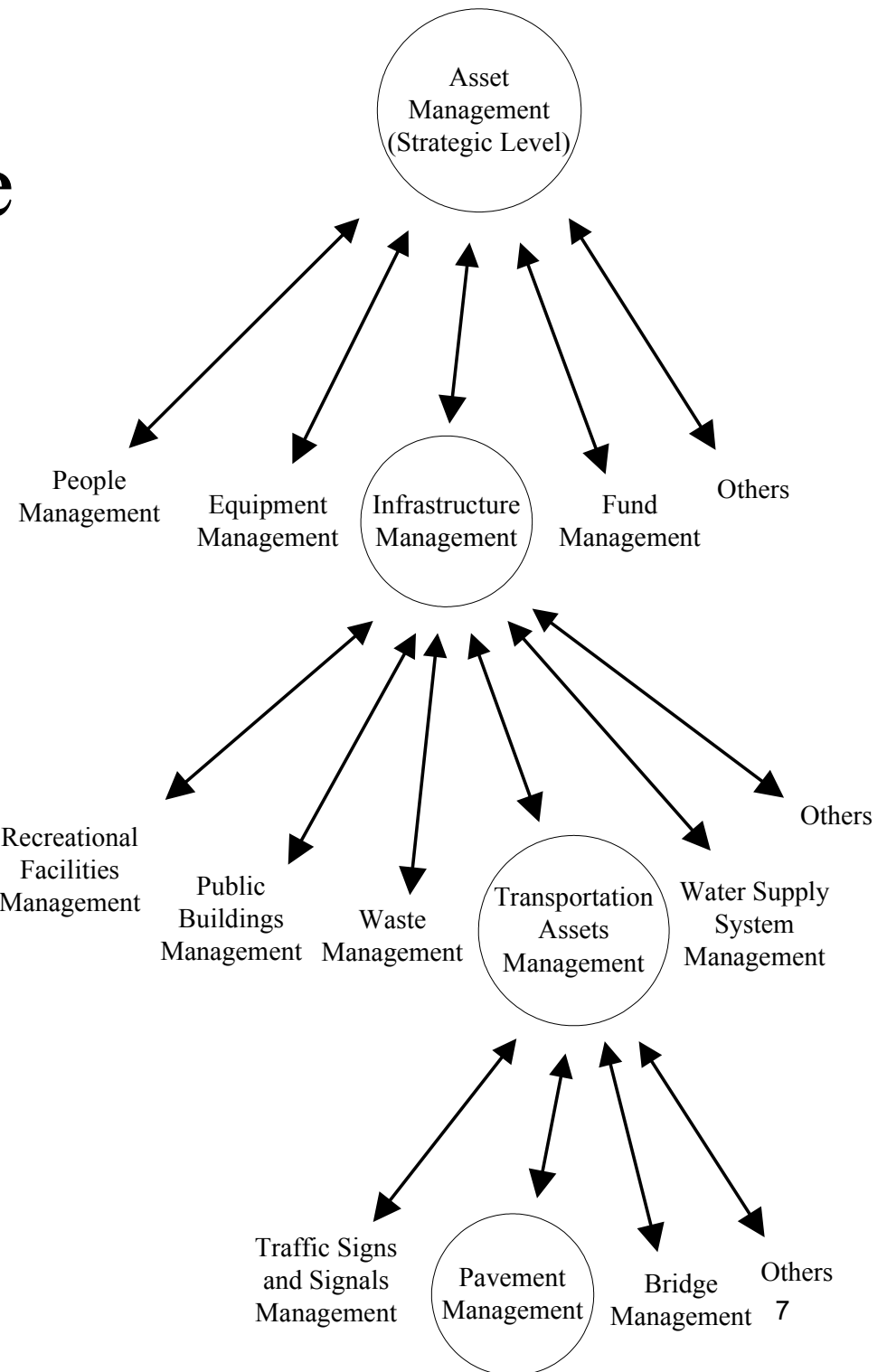
Infrastructure Asset Management Framework

Goals and Policies

Asset Inventory

Condition Assessment and Performance Modelling

Alternatives Evaluation and Program Optimization

Budget/ Allocation

Feedback

Short- and Long-Range Plans (Project Selection)

Program Implementation

Performance Monitoring

# Operate in Management Levels

- ***Strategic (asset) – planning, programming & allocation for all systems***

- ***Network - planning & programming for entire set of type facility managed***

- *Project selection - programming a subset*

- Project

  - Designing a specific section

  - Constructing specific section

# Asset and Infrastructure Management

Strategic Levels

***Differences in What is Managed***

Network Level

Asset Management (Strategic Level)

People Management

Equipment Management

Infrastructure Management

Fund Management

Others

Recreational Facilities Management

Public Buildings Management

Waste Management

Transportation Assets Management

Water Supply System Management

Others

Traffic Signs and Signals Management

Pavement Management

Bridge Management

Others

# Pavement Management System or PMS Software

- Decision support tool
  - Stores data
  - Provides information
  - Prepares reports & graphs
- Help make cost-effective decisions
  - Network-level
  - Some help at project selection-level
  - Existing pavement system

# Purpose of Network-Level

- An investment analysis
    - Related to the budget process
    - Identify maintenance and rehabilitation needs
    - Show impact of funding options

- Communicate with funding authorities

*Interacts with Strategic-level*

# Network-Level Questions to Address

- Funds needed – long-term
  - To provide selected level-of-service
  - Impact of spending less
  - Impact of spending differently
- Funds set – short-term
  - Which segments give best potential return on funds
  - Impact of repairing different segments
  - Impact of applying different treatments
  - Impact of applying treatments at different times

# Purpose of Project-Selection-Level

- Select sections for funding in near-term
    - Capital improvement program – major work
    - Seal program
    - Etc.
- Avoid conflicts with other systems
- Refine alternative treatments

*Input from Network-level*

# Purpose of Project-Level

- Develop cost-effective strategy for:
    - Original construction
    - Maintenance
    - Rehabilitation
    - Reconstruction
- Within imposed constraints
- Complete design and work

*Input from Project Selection-level*

# Differences in Data

- Project-level
  - Detailed data needed to complete designs and plans
- Project-selection level
  - Enough to compare preliminary alternatives for some sections
- Network-level
  - Enough to identify best group of candidate sections & funding impacts

# Those Responsible Vary

- Differences Depend on:
  - Centralized, Decentralized, Public Private Partnerships or Privatized
  - Funding Source
    - Capital vs Maintenance
    - Enterprise vs General vs Dedicated Funds
  - Importance of Facility
  - Organizational & Historical Relationships

# Network-Level Elements

- Inventory
- Condition Assessment
- Determination of Needed Work & Funds
- Identification of Candidate Projects
- Determination of Impacts of Funding Alternatives
- Feedback

# Treatment Assignment Used in

- Inventory
- Condition Assessment
- ***Determination of Needed Work & Funds***
- ***Identification of Candidate Projects***
- ***Determination of Impacts of Funding Alternatives***
- Feedback

# Network-Level Methods

- ☐ Identify intervention (Treatment) levels
  - ■ Combine with projected condition for each segment

- ☐ Often use "Trigger Values"
  - ■ Trigger a treatment

# Condition at Time to Intervene Often Reflected in "Trigger Values"



CI

Single Trigger Value

Not Ready

Not Ready

Not Ready

Do Something

Should have had work aleady

Time or Usage
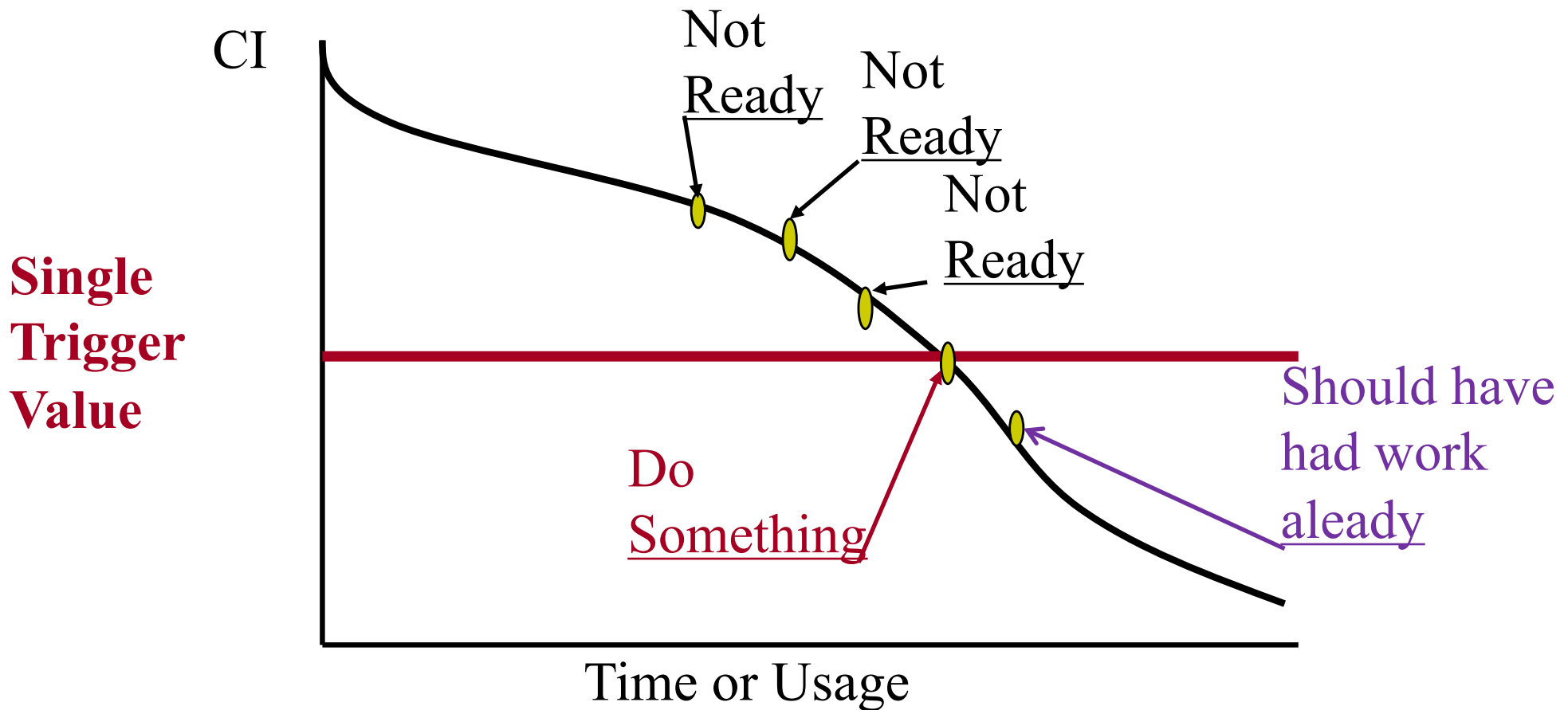
# Multiple Possible Treatment Levels

Light Work or
Preventive Maintenance

Moderate Work

CI

Heavy Work

Reconstruct

Time or Usage
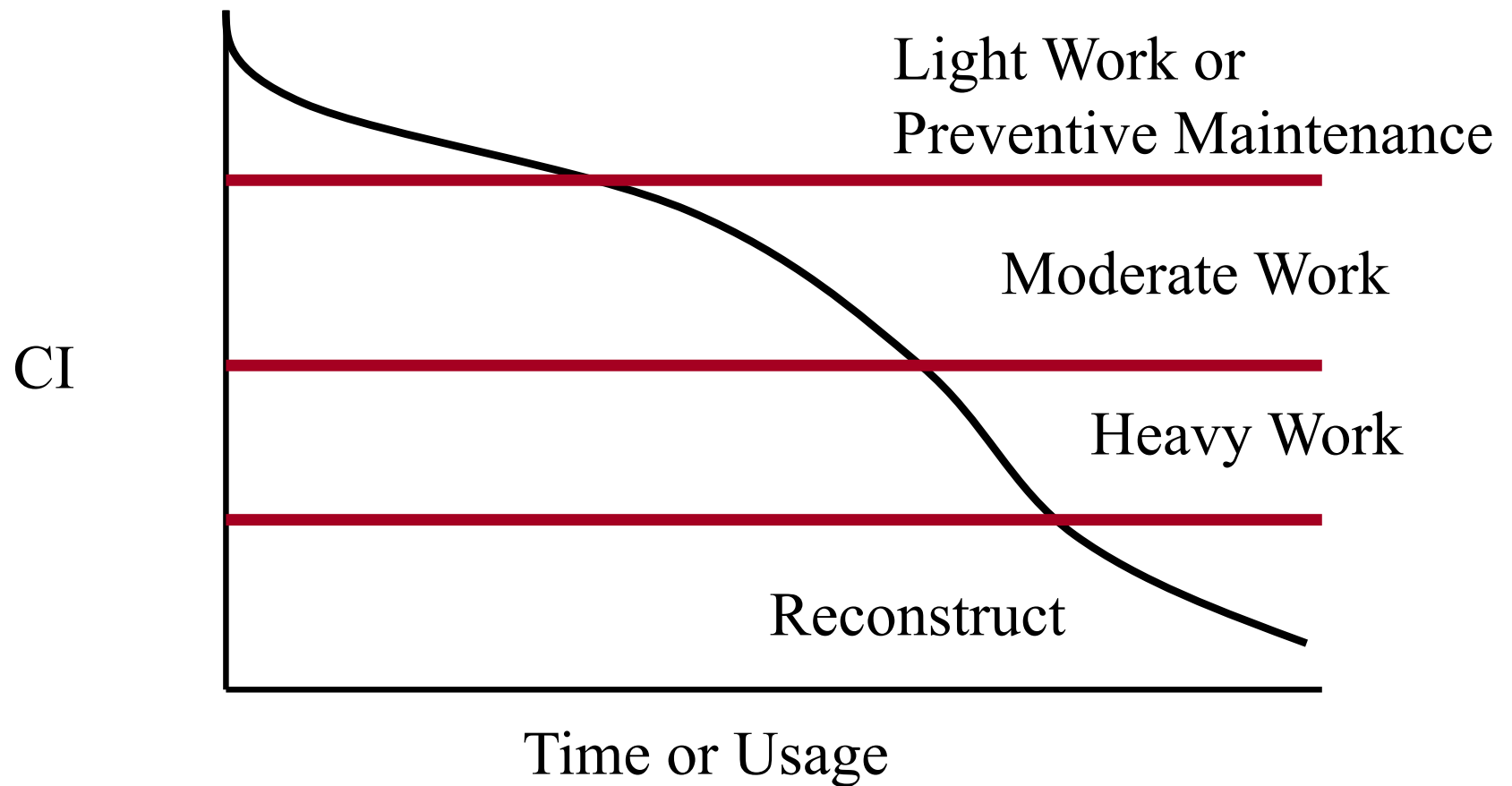
# Multiple Trigger Value Levels

Do Moderate Work

CI

Trigger Value 1

Do Heavy Work

Trigger Value 2

Reconstruct

Trigger Value 3

Time or Usage
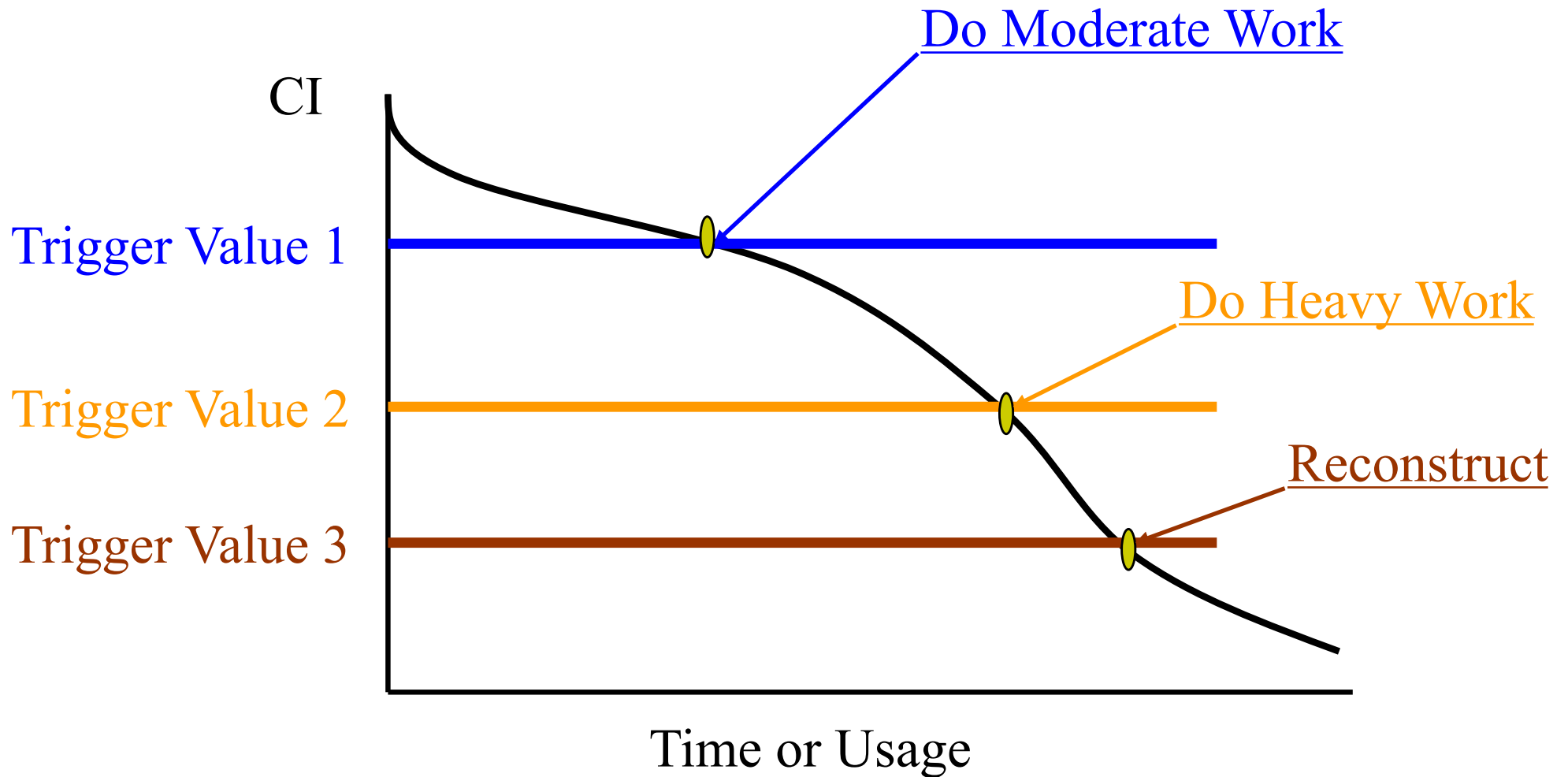
# Advantages of Multiple Values

- Allows multiple intervention points

- When a PM treatment is not applied, moderate treatment can be identified before reconstruction is required

# Factors to Consider in Setting Values

- Distress ID system & CI calculation method
- Type of pavement surface
  - AC vs PCC
- Importance of road/street
  - Arterial vs residential
- Usage/load level
  - AADT
  - AADTT

# Adjust Levels For Importance/Usage

## Moderate Level Trigger Value (TV)



CI

Do Something
To Arterials

Do Something
To Collectors

Do Something
To Residentials

Arterial TV

Collector TV

Residential TV

Age
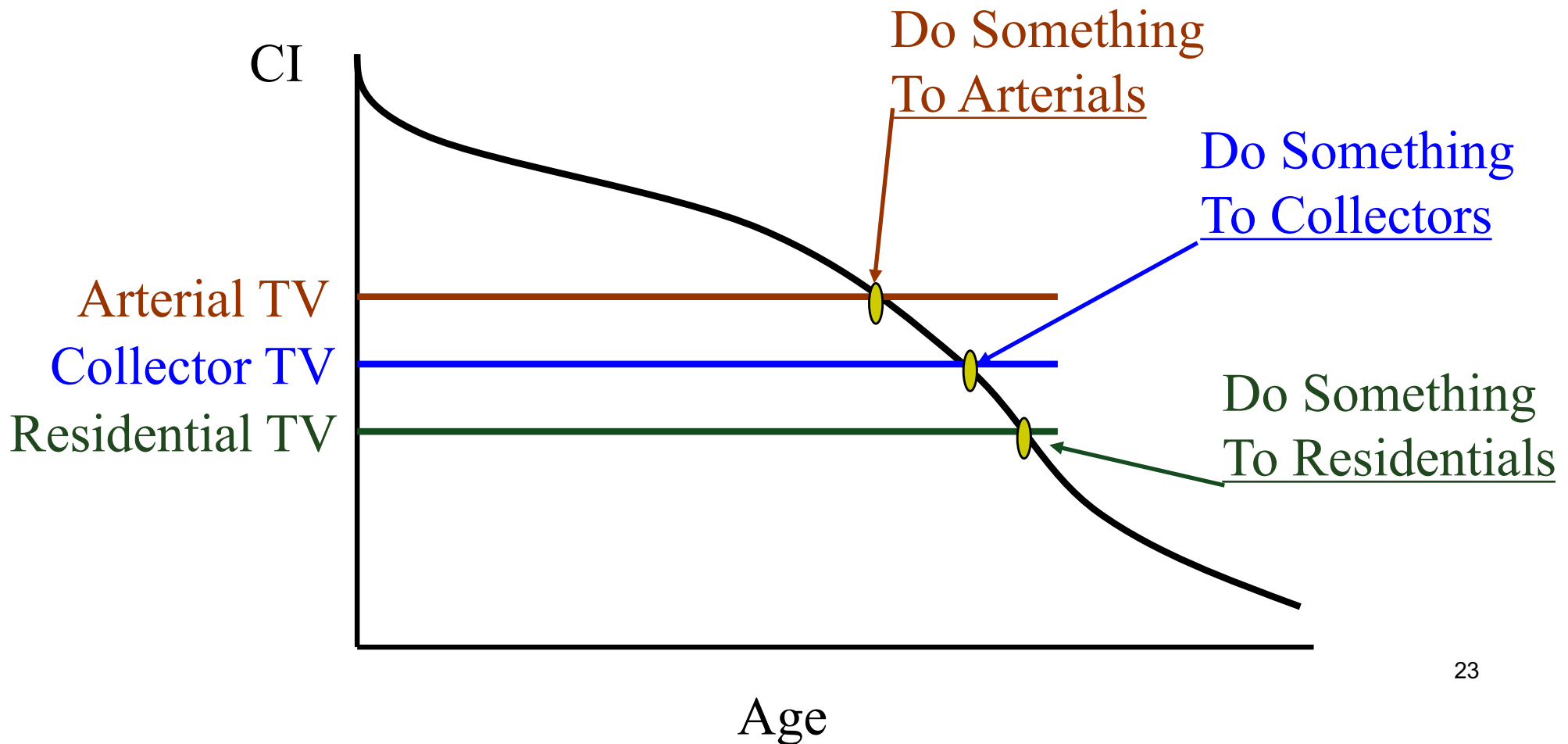
# Preventive Maintenance - Time Driven?

7 yrs  7 yrs  7 yrs

Apply slurry seal

Do Moderate Work

Trigger Value 1

CI

Age
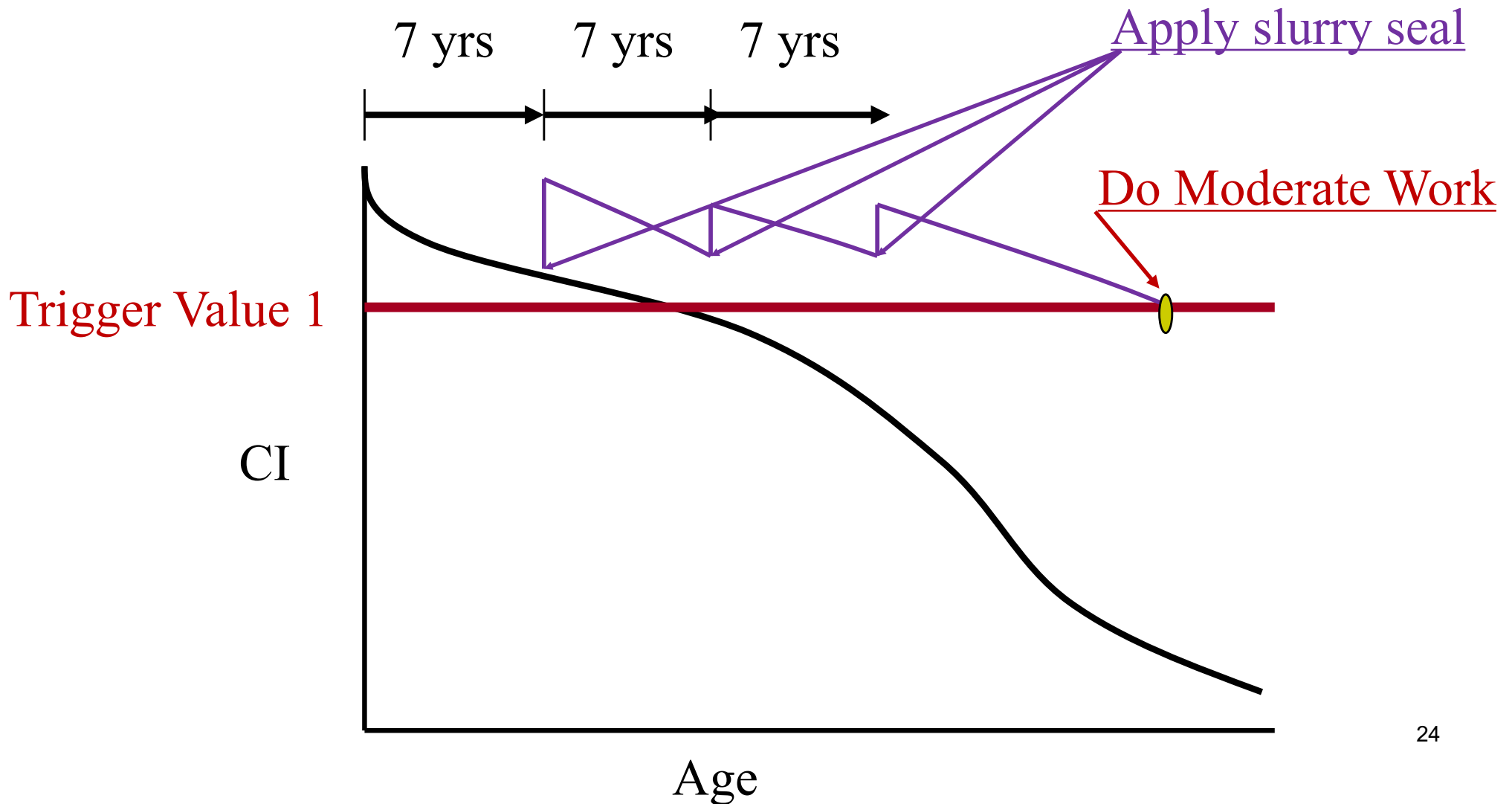
# Combine Trigger Values with Other Factors

- Inventory Data
  - Importance (functional classification, etc.)
  - Usage level (high vs low)
  - Material types (PCC vs HMAC)
  - Construction dates

# One of These for Every Combination
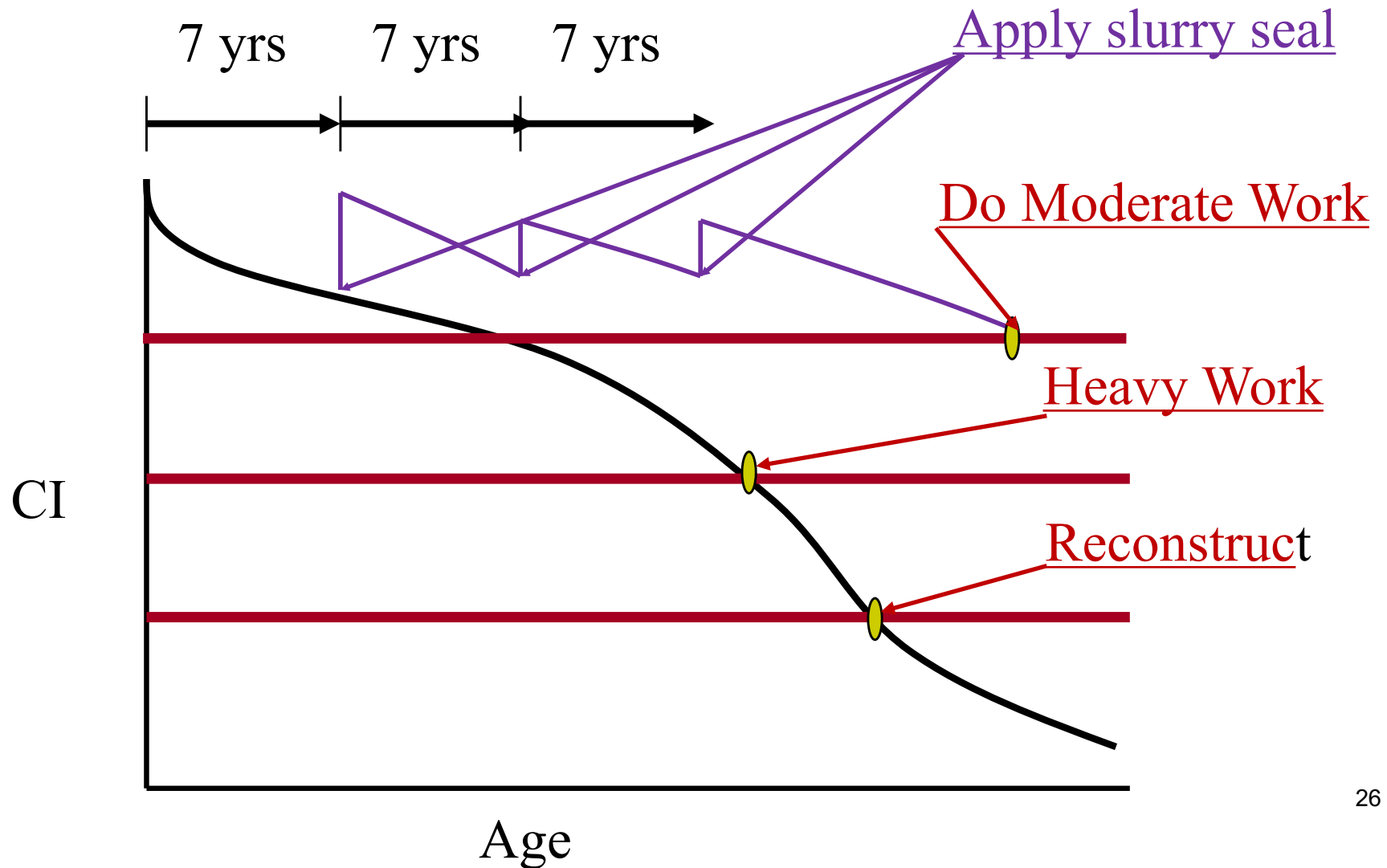
# Methods for Combining Factors

☐ Rules

☐ Decision Trees

☐ Decision Matrices

☐ Artificial Neural Networks

☐ Etc.

# Rules

- Rules of thumb from decision makers
- Sounds simple
- Often develops conflicts
- Difficult to maintain
- Difficult to check/validate

# Decision Tree

- Method of combining information to choose between several options

- Structured method to identify appropriate options

  - Assign appropriate treatment

- Allows visualization of complex process

- Often end up with several final branches and resulting decision recommendations

# Example Decision Tree
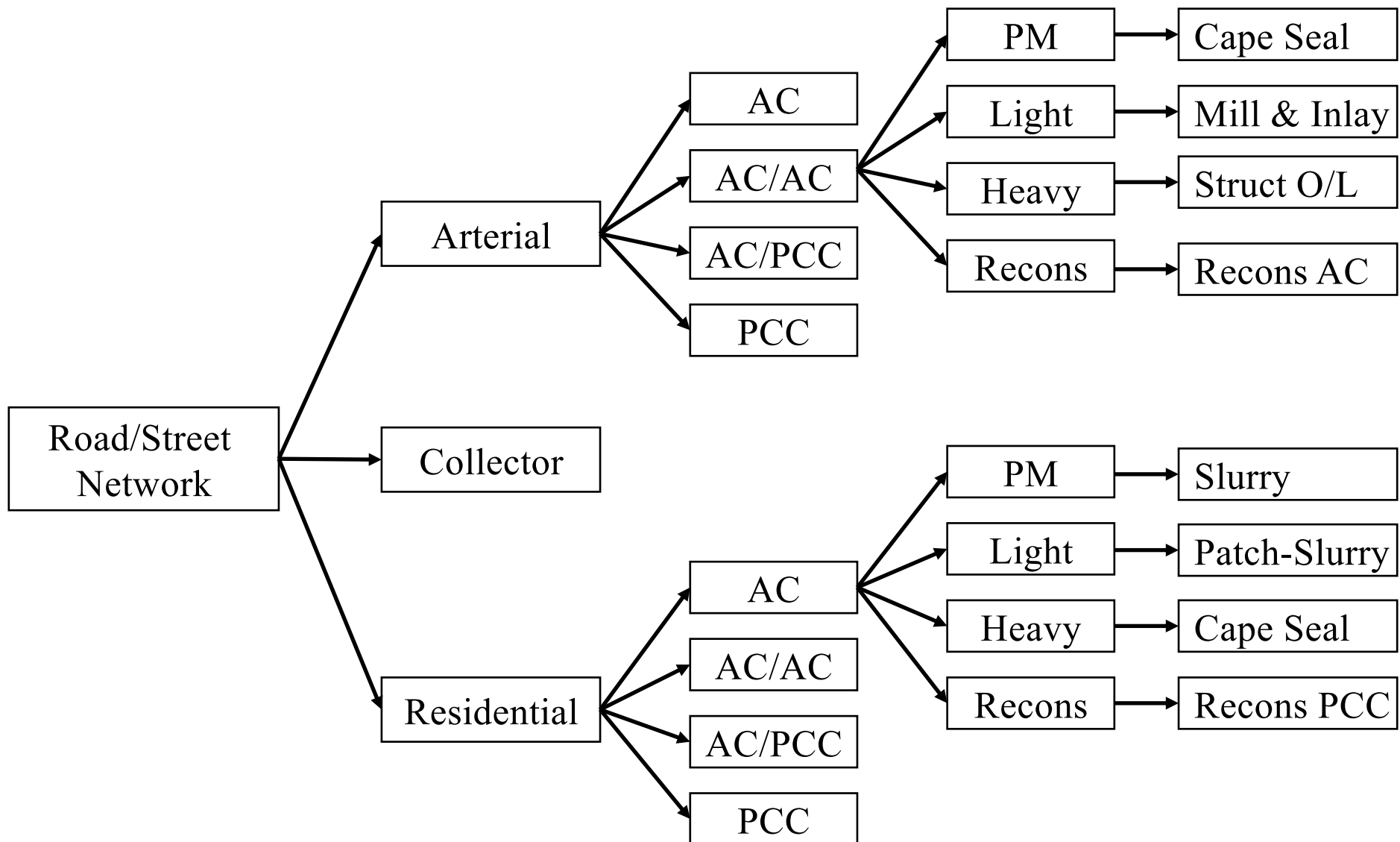
# Decision Matrices

- Decision trees become difficult to visually represent when there are many branches
- Decision matrices similar to decision tree
    - May be easier to visualize with many branches
- Uses sequences of imbedded matrices
- Allows multiple treatments

# Treatment Matrix for Pavements

| | | Functional Classification | | |
|---|---|---|---|---|
| | | Art | Col | Res |
| Surface Type | AC | Con AA | Con AC | Con AR |
| | AC/PCC | Con CA | Con CC | Con CR |
| | PCC | Con PA | Con PC | Con PR |

Con CC – Condition Matrix for Composite Collector

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# Condition Matrix for Composite Collector (Con CC) Imbedded in Prior Matrix

| PM | Light | Mod Rehab | Heavy Rehab | Reconstruct |
|---|---|---|---|---|
| Chip Seal | Thin Overlay | Patch & O/L | Struct O/L | Rec-AC |
| Slurry Seal | O/L w Fabric | Hot Inplace Recycle | Mill & Struct O/L | Rec-PCC |
| Cape Seal | Mill & Thin O/L | Mill & O/L | Cold Recycle & O/L | |

# Decision Matrix

Treatment Matrix

Functional Classification

**Surface Type**

| | Art | Col | Res |
|---|---|---|---|
| AC | Con AA | Con AC | Con AR |
| AC/PCC | Con CA | Con CC | Con CR |
| PCC | Con PA | Con PC | Con PR |

Condition Matrix for Composite Collector

| PM | Light | Mod Rehab | Heavy Rehab | Recon struct |
|---|---|---|---|---|
| Chip Seal | Thin Overlay | Patch & O/L | Struct O/L | Rec-AC |
| Slurry Seal | O/L w/ Fabric | Hot Inplace Remix | Mill & Str O/L | Rec-PCC |
| Cape Seal | Mill & O/L | Mill & Overlay | Cold Rec & O/L | |

**LCCA is performed during each run of the software to select most cost-effective treatment**

# Decision Matrices

- With many combinations

- Decision appear to be more of a black box

- More complex to set up

- More complex to maintain

- More difficult to check/validate

# Artificial Neural Networks

Allows unlimited combinations
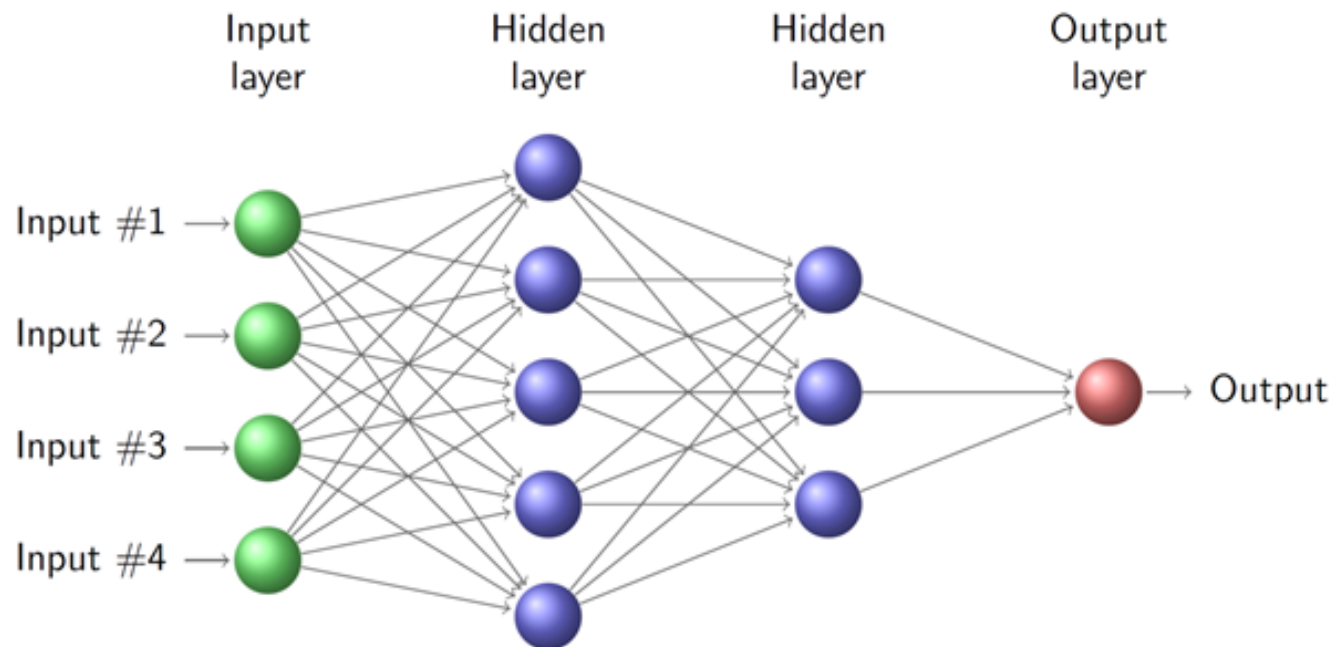
# Artificial Neural Networks

- Require special expertise

- Require many (hundreds or thousands) of training runs

- Generally black box to most users

- Very difficult to maintain

- Very difficult to check/validate

# Back to Network-Level Questions

- Fund needed – long-term
  - To provide selected level-of-service
  - Impact of spending less
  - Impact of spending differently
- Funds set – short-term
  - Which segments give best potential return on funds
  - Impact of repairing different segments
  - Impact of applying different treatments
  - Impact of applying treatments at different times

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# Treatment vs Treatment Category

□ At network level

  ■ ***Treatment category*** rather than actual treatment

  ■ Cost estimating treatment

□ Level of funding more important than actual treatment

  ■ Treatment refined in project selection-level

  ■ Treatment selected in project-level

□ Treatment Name needed to develop costs

# Network-Level Activities Depending on Treatment Assignment

- Inventory

- Condition Assessment

- ***Determination of needed work & funds***

- ***Identification of candidate projects***

- ***Determination of impacts of funding alternatives***

- Feedback & Upkeep

# Decision Trees often Used

- When factors are relatively small

- Easier to visualize connections

- Easier to maintain

# StreetSaver® Decision Trees

- ☐ Connect selected information to a treatment

- ☐ Network-level planning treatment
  - ■ Assigned each section needing work
  - ■ During analysis period (5 to 30 yrs)
  - ■ Costs connected to treatments

# Factors Considered in StreetSaver®

□ Condition

- Projected PCI

- Cause of damage

□ Functional classification

- Usage

- Construction

□ Surface type

- Construction

# StreetSaver® Decision Trees
# Functional Class – Surface Type

Level of Importance
Functional Classification

Surface Type

**Arterial**
- AC
- AC/AC
- PCC
- AC/PCC
- ST

**Collector**
- AC
- AC/AC
- PCC
- AC/PCC
- ST

**Residential/Local**
- AC
- AC/AC
- PCC
- AC/PCC
- ST

**Other**
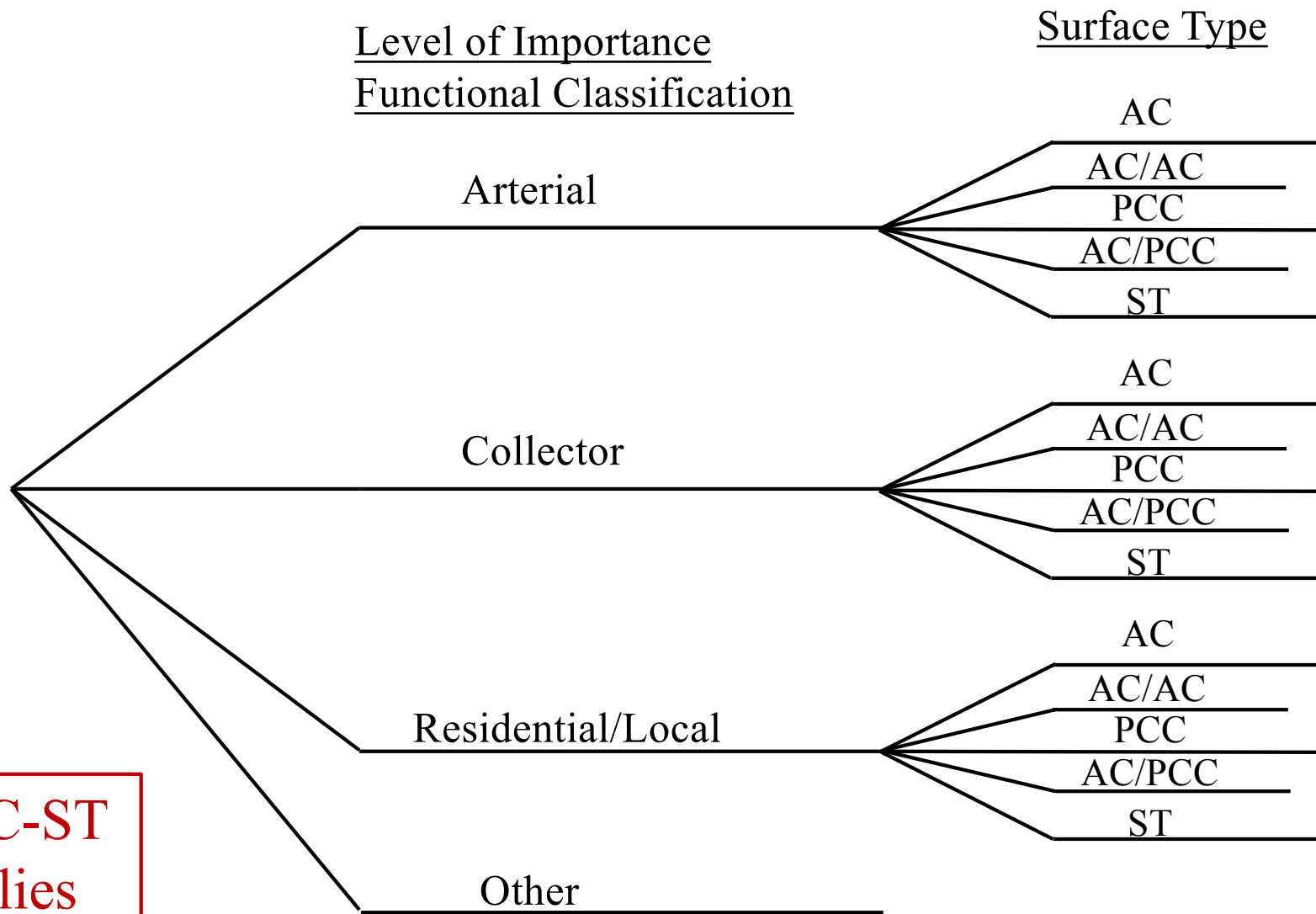
20 FC-ST
Families

# StreetSaver® Decision Tree
# Condition/Treatment Categories

Functional Class

Surface Type

Condition Category/
Treatment Level

Very Good/Cat I

Good-Non Load/Cat II

Good-Load/Cat III

Poor/Cat IV

Very Poor/Cat V
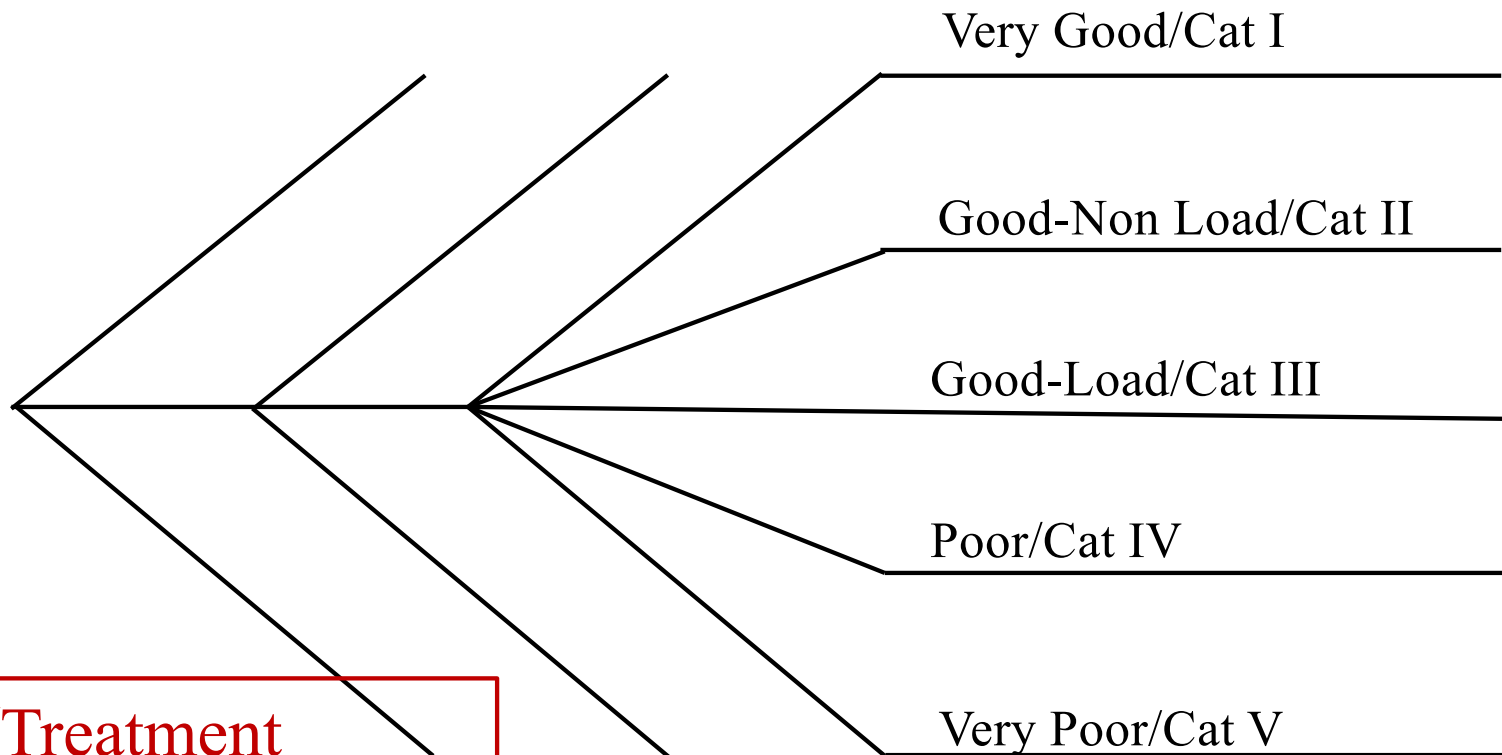
5 Condition/Treatment
Categories per FC-ST Family

# StreetSaver® Condition Categories

| | |
|---|---|
| 100 | |
| | Category I |
| 70 | |
| Category II — Non-Load / Load | Category III |
| 50 | |
| | Category IV |
| 25 | |
| | Category V |
| 0 | |
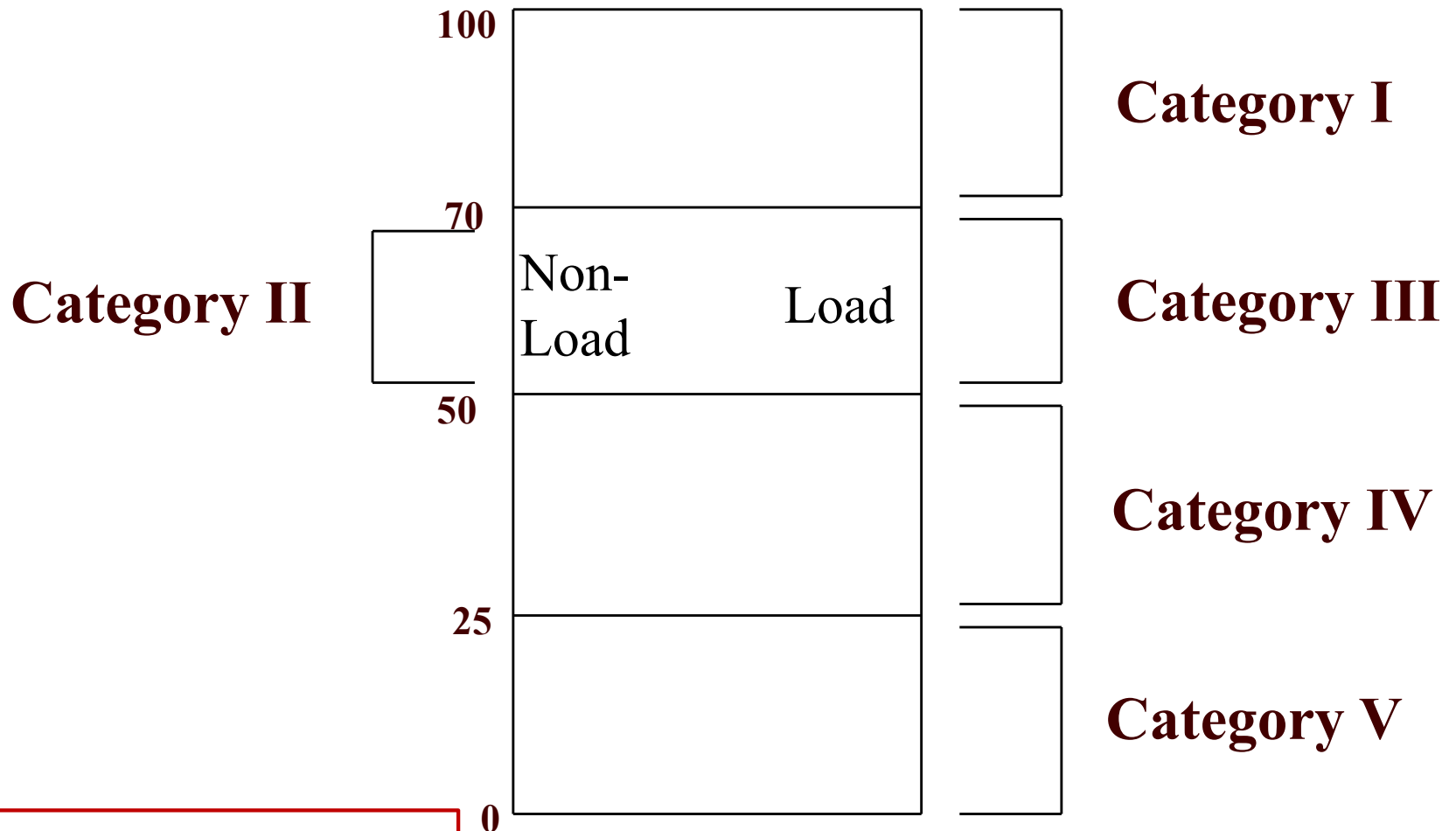
5 Condition/Treatment
Categories per FC-ST Family

# Default Trigger Values
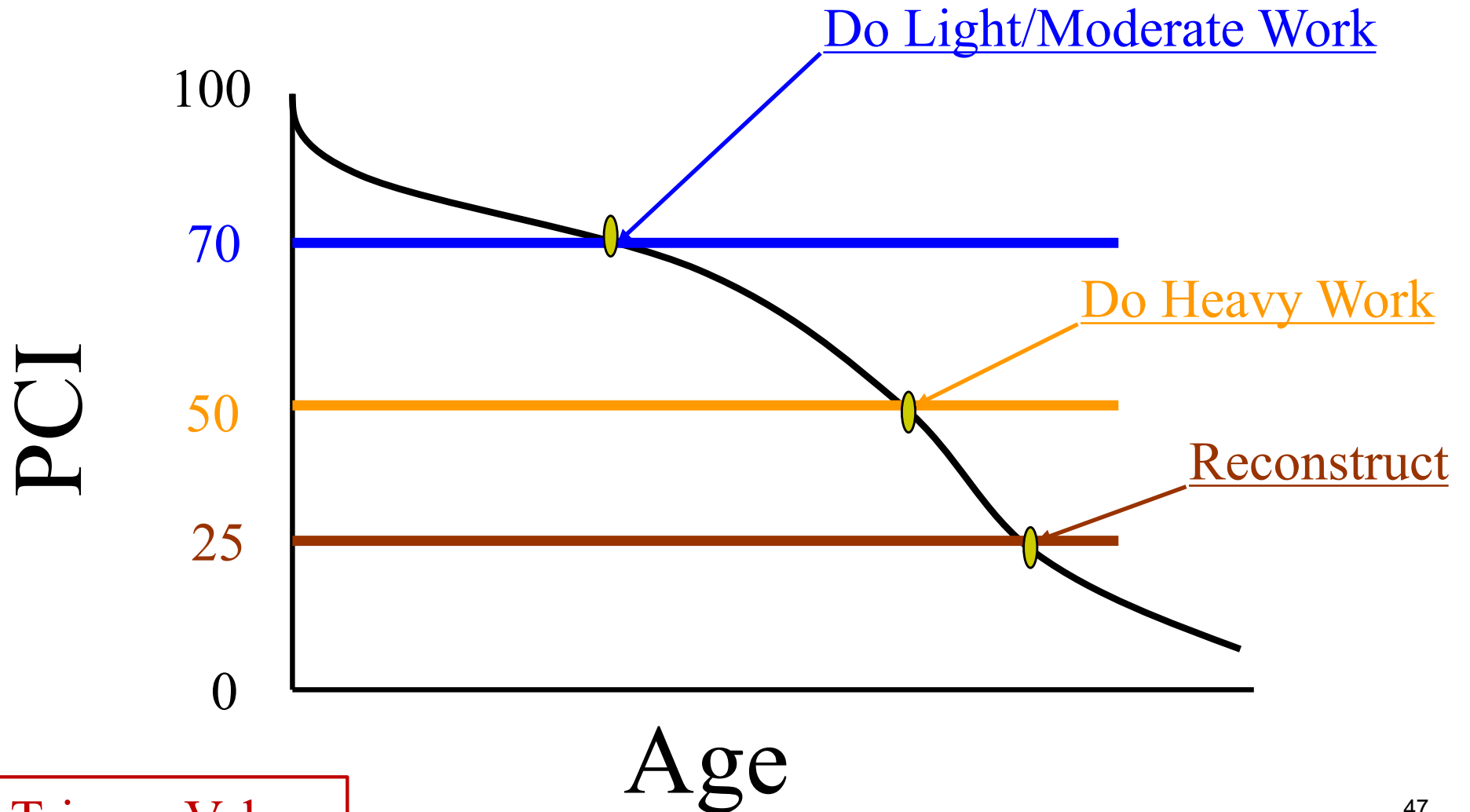


60 Trigger Values

# Set/Changed in Table Maintenance



No treatment will be applied if PCI is greater than PCI Cap

60 Trigger Values Plus 20 PCI Caps

# Rehabilitation Treatment

- ❑ Identified for application when PCI projected to reach one of the Cat II/III, IV, and V trigger values

- ❑ Can still be a seal – normally with significant surface repair prior to treatment

- ❑ Localized & Do-Nothing can be used

# PM in StreetSaver®

- ☐ PCI applied above Cat II trigger value

- ☐ Projected to remain above for the next three years

- ☐ Applied based on

  - ■ Time of last treatment

    and

  - ■ Designated sequence time

# PM in StreetSaver®

- Surface seal
    - Enter treatment
    - Enter years between application
    - Enter max number of sequential seals
- Application interval begins
    - At construction
    - At overlay
    - At surface seal

# PM in StreetSaver®

- Crack seal
  - Enter treatment
  - Enter years between application
- Application interval begins
  - At construction
  - At overlay
  - At surface seal

# Max Number of Surface Seals Reached

7 yrs    7 yrs    7 yrs

Apply slurry seal

Restoration Treatment

70

CI

Age
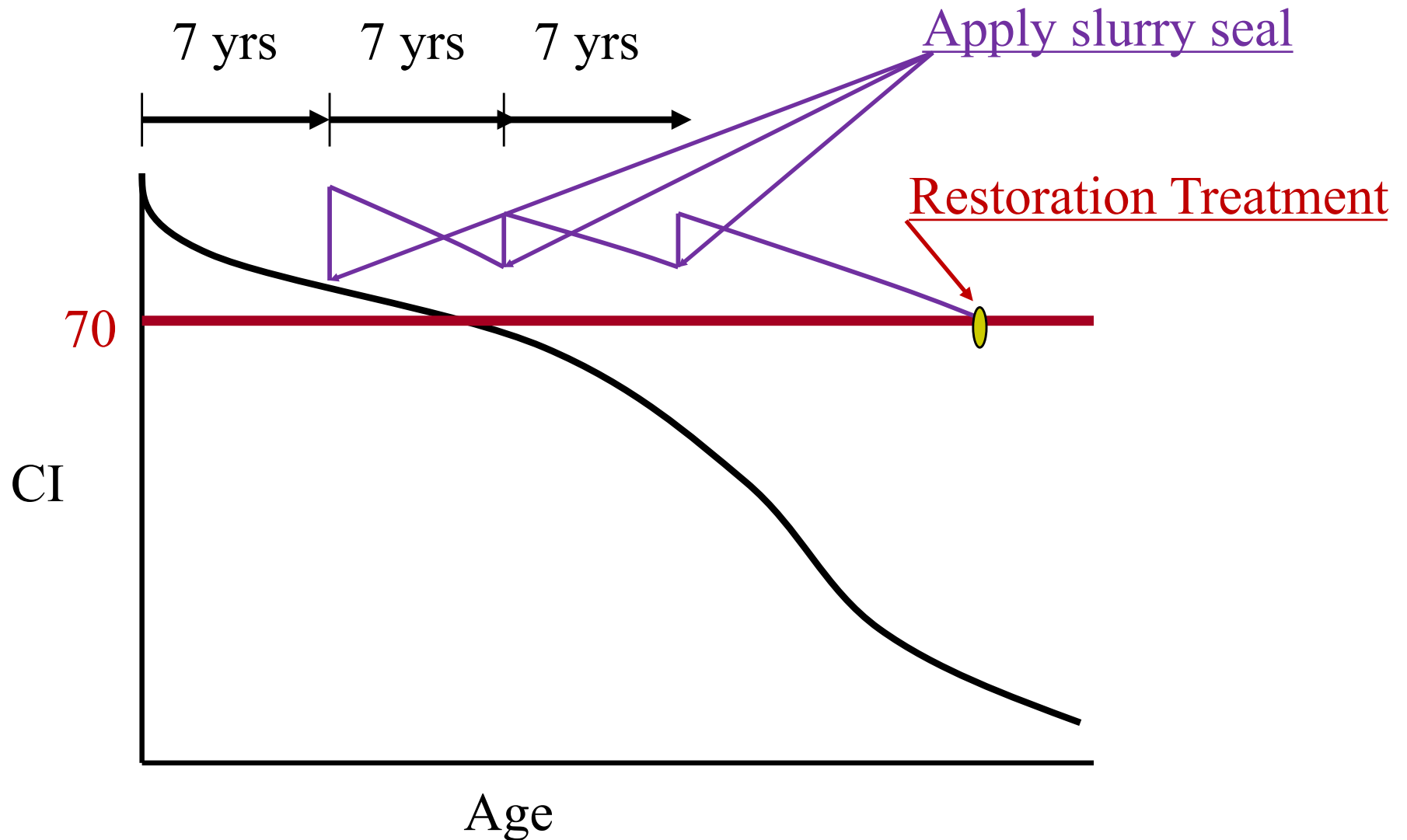
# Restoration Treatment

- When maximum number of seals reached
  - No further seals
  - Programmed for restoration treatment when PCI reaches Cat II/III trigger value
- Based on issues of instability created by several sequential seals
- Normally includes a mill & overlay

# Assign Treatment Categories to Each Decision Tree Branch

Functional Class

Condition Category

Surface Type

Treatment Level Cost

Very Good/Cat I — Preventive Maintenance $1.50/sy

Good-Non Load/Cat II — Light Rehabilitation $2.50/sy

Good-Load/Cat III — Light Rehabilitation $4.50/sy

Poor/Cat IV — Heavy Rehabilitation $15.00/sy

Very Poor/Cat V — Reconstruct $75.00/sy
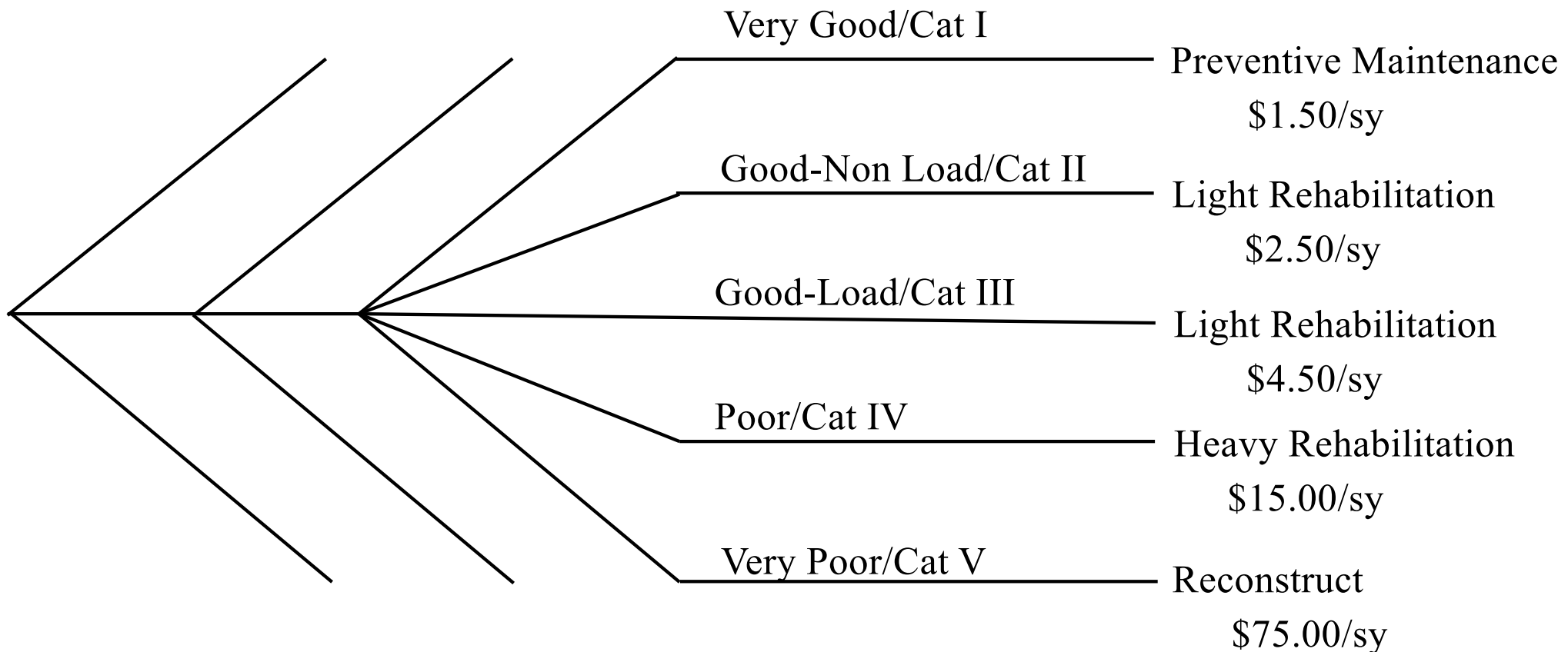
# Can Only Select Established Treatments

# User Can Add Other Treatments

- Users can add their treatments to the list of treatments

- No constraints on names

  - "Howard's favorite treatment" could be use

  - But use the names your agency recognizes

- Must also select "Overly code"

  - Controls post treatment condition and surface changes

# Overlay & Reconstruction (O & R)

New Family Curve

100

PCI

Projected Condition

PCI Increase

0

Overlay

Age
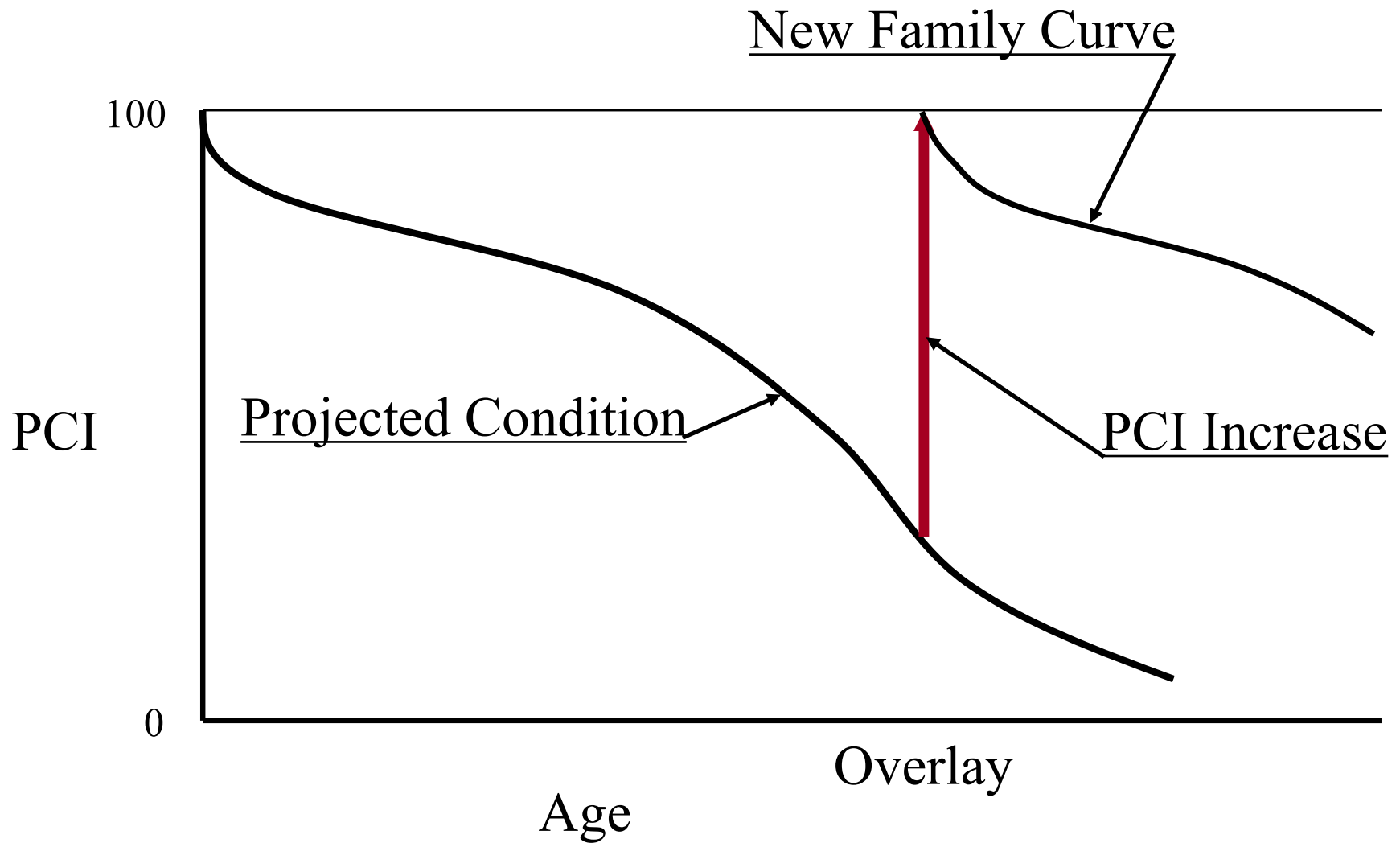
# Surface Seal, Crack Seal, Localized (S, C, & L)



PCI Increase

Shifted Curve

Projected Condition

PCI

100

0

C, S, L Treatment

Age
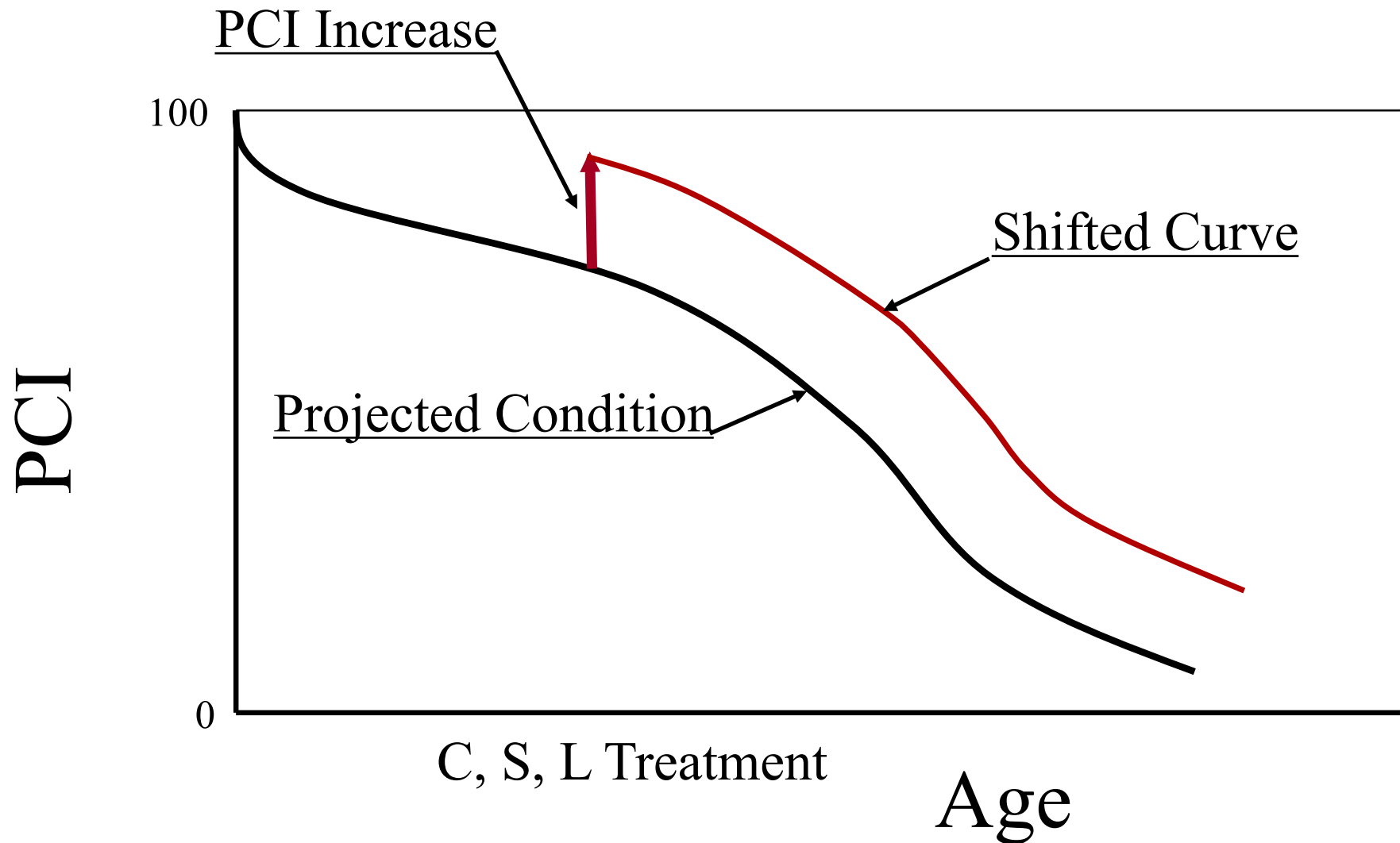
# All StreetSaver® Databases Have Default Decision Trees
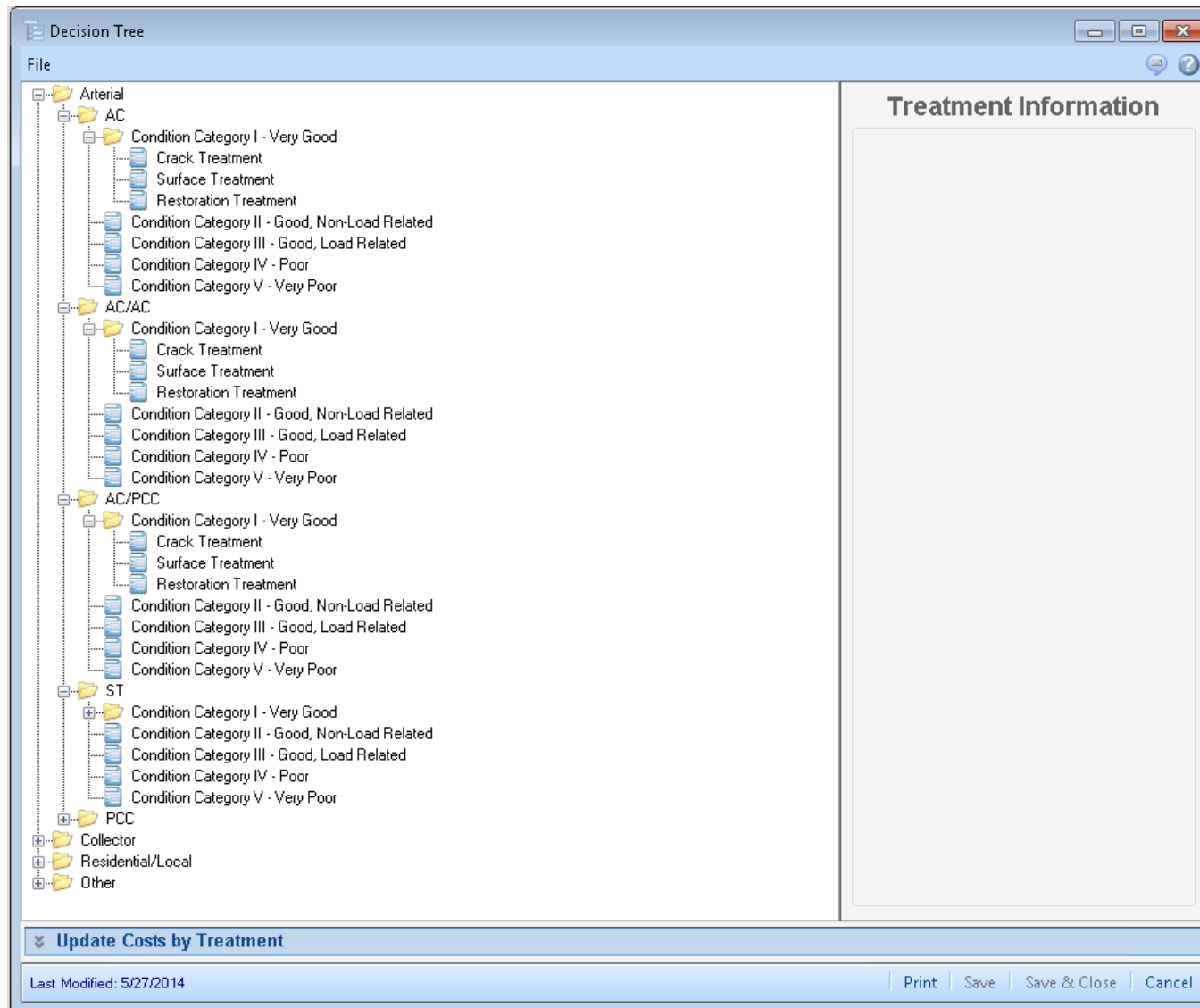
# Treatments and Unit Costs

□ Default – User modifiable

□ Agencies need to modify to reflect their:

- ■ Treatments
- ■ Unit costs

□ Cost will affect the calculated needs

# Seven Treatments for
# Each FC/ST Combination

□ 3 PM

□ 4 Rehab

# All Seals Require Time Between Seals

# Maximum Number of Surface Seals

- Can set maximum number of surface Seals (AC, AC/AC, AC/PCC)

- Once maximum reached, no additional surface seals applied
  - Restoration treatment applied when PCI reaches 70
  - Rehab - next rehab treatment that is not a surface seal

# Restoration Treatments Require Maximum Number of Seals

# Seals Can be Applied as Rehabilitation

# Years between seals = 99
# Maximum numbers of seals = 100

# Non-seals Do Not Have Years Between Treatments

# Report Lists Current Treatments

MTC 7 Distress

**Decision Tree**

Printed: 03/25/2015

| Functional Class | Surface | Condition Category | Treatment Type | Treatment | Cost/Sq Yd, except Seal Cracks in LF. | Yrs Between Crack Seals | Yrs Between Surface Seals | # of Surface Seals before Overlay |
|---|---|---|---|---|---|---|---|---|
| Arterial | AC | I - Very Good | Crack Treatment | Crack Seal (C) | $1.39 | 2 | | |
| | | | Surface Treatment | Seal Coat (S) | $2.96 | | 5 | |
| | | | Restoration Treatment | RH1 MILL AND THICK OVERLAY | $18.00 | | | 3 |
| | | II - Good, Non-Load Related | | RH2 SINGLE CHIP SEAL | $3.26 | | 5 | |
| | | III - Good, Load Related | | RH3 THIN AC OVERLAY(1.5 IN) | $9.14 | | | |
| | | IV - Poor | | RH4 THICK AC OVERLAY(2.5 IN) | $21.46 | | | |
| | | V - Very Poor | | RH5 RECONSTRUCTION W/AC | $48.91 | | | |
| | AC/AC | I - Very Good | Crack Treatment | Crack Seal (C) | $1.39 | 2 | | |
| | | | Surface Treatment | Seal Coat (S) | $1.91 | | 5 | |
| | | | Restoration Treatment | RH1 MILL AND THICK OVERLAY | $25.00 | | | 2 |
| | | II - Good, Non-Load Related | | RH2 DOUBLE CHIP SEAL | $5.00 | | 5 | |
| | | III - Good, Load Related | | RH3 HEATER SCARIFY OVERLAY | $18.33 | | | |
| | | IV - Poor | | RH4 HEATER SCARIFY OVERLAY | $18.91 | | | |
| | | V - Very Poor | | RH5 RECONSTRUCTION W/AC | $48.91 | | | |
| | AC/PCC | I - Very Good | Crack Treatment | Crack Seal (C) | $1.39 | 2 | | |
| | | | Surface Treatment | Seal Coat (S) | $1.91 | | 5 | |
| | | | Restoration Treatment | RH1 MILL AND THICK OVERLAY | $25.00 | | | 2 |
| | | II - Good, Non-Load Related | | RH2 DOUBLE CHIP SEAL | $5.00 | | 5 | |
| | | III - Good, Load Related | | RH3 HEATER SCARIFY OVERLAY | $18.33 | | | |
| | | IV - Poor | | RH4 HEATER SCARIFY OVERLAY | $18.91 | | | |
| | | V - Very Poor | | RH5 RECONSTRUCTION W/AC | $48.91 | | | |
| | PCC | I - Very Good | Crack Treatment | Crack Seal (C) | $1.39 | 5 | | |
| | | | Surface Treatment | DO NOTHING | $0.00 | | 99 | |
| | | | Restoration Treatment | DO NOTHING | $0.00 | | | 100 |
| | | II - Good, Non-Load Related | | DO NOTHING | $0.00 | | | |
| | | III - Good, Load Related | | DO NOTHING | $0.00 | | | |
| | | IV - Poor | | RH4 THICK AC OVERLAY(2.5 IN) | $50.00 | | | |
| | | V - Very Poor | | RH5 SEAL CRACKS PCC THIN OL/FABRIC | $72.50 | | | |

MTC 7 Distress

# Decision Tree

Printed: 03/25/2015

| Functional Class | Surface | Condition Category | Treatment Type | Treatment | Cost/Sq Yd, except Seal Cracks in LF: | Yrs Between Crack Seals | Yrs Between Surface Seals | # of Surface Seals before Overlay |
|---|---|---|---|---|---|---|---|---|
| Arterial | ST | I - Very Good | Crack Treatment | Crack Seal (C) | $1.39 | 2 | | |
| | | | Surface Treatment | DO NOTHING | $0.00 | | 99 | |
| | | | Restoration Treatment | DO NOTHING | $0.00 | | | 100 |
| | | II - Good, Non-Load Related | | RH2 SINGLE CHIP SEAL | $3.26 | | | |
| | | III - Good, Load Related | | RH3 SINGLE CHIP SEAL | $4.65 | | | |
| | | IV - Poor | | RH4 SINGLE CHIP SEAL | $7.00 | | | |
| | | V - Very Poor | | RH5 THICK AC OVERLAY(2.5 IN) | $23.62 | | | |

# Selecting Appropriate Treatments

- Engineering knowledge & Engineering economics

- Life Cycle Cost Analysis (LCCA)
  - Uses economic principles to compare investment in competing treatments & strategies
  - Among candidate treatments for a specific segment type
  - Determine which is generally most cost effective

- Based on historical data for similar work

# Pavement Preservation Strategies

- Apply:
  - The right treatment
  - To the right pavement
  - At the right time
- Focuses on preventive maintenance
  - Dedicate funds to preventive maintenance

# Planning Treatment/Cost Category

- Cost more important than actual treatment

- Actual treatment selected later in Project-Selection & Project Levels

# Preferred Method

- Conduct a series of life-cycle cost analyses to identify the most cost effective set of treatments for

  - Each FC/ST combination for

  - Each condition category

- For StreetSaver® - 4 FC's, 4 ST's, 5 CC's - but PM has 3 treatments

  - 112 total treatment/cost categories

# General Approach

- 1 - Treatment generally applied historically

- 2 – Treatment that agency believes should generally be applied

- 3 – Other?

# What Are In the Unit Costs

- Costs to the agency
  - Engineering
  - Contract or
  - Labor, equipment & material
- Includes prudent preparation work
  - Crack sealing
  - Localized repairs

# Cost Determination

- For the "typical" treatment in decision tree or matrix

- Determine average treatment unit costs

- Unit costs multiplied by segment area

  - Results in segment treatment cost

- Accumulated for network (or sub-group) fund needs

# Typical Approach for Determining Network-level Unit Costs

☐ Estimate costs (cost estimating processes)

- Opinions based on analysis and judgment
- Engineering estimates

☐ Check historical costs of completed work on segments in similar condition and parameter groups (families)

☐ Consider appropriate, but only, analyzed costs

- Don't include costs of inlet replacement in street repair costs if they come from drainage funds

# How Do You Determine?

- Historical costs
    - Past contracts - check work included
    - Past agency costs

- Neighbor costs - check on what is included

# Feedback Activity

- At end of construction season

- Review treatments applied

  - Do you need to change decision tree treatment?

  - Was the treatment applied the appropriate treatment or "stop-gap" treatment?

- Review costs for treatments

  - Adjust costs to reflect those from the latest season

# Questions

?